Identification of the Carcass Trawled by the Zuiyo-maru*

— From a Comparative Morphological Viewpoint —

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Introduction

At the request of Taiyo Fishery Company, an attempt was made to examine from a comparative morphological viewpoint the taxonomic affiliation of the carcass captured by the Zuiyo-maru, based on the information provided by the company, i.e. a) four photographs showing the external features of the carcass (Pl. 1), b) a sketch with some measurements of the carcass (Pl. 2), c) horny fibers collected from the carcass, as well as on the observation of the carcass made by Mr. Michihiko Yano. Our inquiries to him about the details of these pieces of information revealed that information on the nature of the carcass then prevailing among many people was partly in need of correction. As comparative materials, this study also dealt with cross section photographs of the pectoral fin of a basking shark provided by Dr. Fujio Yasuda of Tokyo University of Fisheries, a specimen of the blue shark made available through the courtesy of Dr. Toru Taniuchi of the University of Tokyo, and several samples of the fore limb of aquatic animals such as cetaceans, manatees and pinnipedians.

Analysis of information

Head part. The measurements made by M. Yano indicate that the over-all length of the carcass was about 10 m, and the skull was small, relative to other parts of the body, being 45 cm in length and about 30 cm in width. According to the sketch, orbits were found in the upper part of the skull, and nares-like foramens were observed. The lower jaw is said to have been already lost and the teeth were missing.

The shape of the head and neck can be seen in the four photographs, of which two show the carcass hung up by a rope viewed from the front left, and one from the back right, while the other one presents a view of the carcass laid down on the deck. It was impossible to tell in detail about the structure of the skull from these photographs. What can be clearly recognized are only that the head had been fairly well skeletonized and there were orbit-like depressions in the head.

Neck part. The neck was long; the distance from the occiput to the presumed

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shoulder girdle is said to be in the vicinity of 1.5 m. The photographs show soft, white tissues, which appear to be ligaments, covering the whole surface of the neck. Though cervical vertebrae are invisible, it appeared from the photographs that the cervical vertebral column was greatly bent when the body was hung up by a rope, attached behind the shoulder girdle. This suggests the tenacious and elastic nature of the intervertebral ligaments. No internal organs were recognized in the neck part.

Pectoral girdle and pectoral and dorsal fins. The two photographs of the carcass taken from the front left (Pl. 1 A, B) indicate the presence of a large skeleton that seems to be the pectoral girdle and the whole view of a pair of pectoral fins, which measured about 1 m in length. The right pectoral fin is also seen in Pl. 1 C. The anterior margin of this fin is straight, while the posterior edge recurved. The fin appears thicker anteriorly than posteriorly. M. Yano sketched another paired fins as long as the anterior pair in the posterior part of the body. The posterior fin does not appear in the photographs.

The two pieces of bone in each of the anterior and posterior fins shown in the sketch (Pl. 2) are quite suggestive of a quadruped animal. These bones, however, are in reality a product of Yano's imagination, resulting from feeling something hard inside the fins when he stepped on them. He did not actually witness and count these bones.

It was observed by Yano that the pectoral and pelvic fins had some 40 to 50 pieces of fibers exposed along their margins from the tip to the rear base. These fibers are clearly seen in the photographs. It was also stated that the fibers were 20 to 30 cm in length, 2 to 3 mm in diameter, and semitransparent with a yellowish tint. Some of these fibers were collected by Yano and have offered the only material utilizable as evidence for the identification of the animal.

Though the dorsal fin has not been mentioned by the eye-witnesses, nor was it shown in the sketch, the whole shape of a dorsal fin can be recognized in one of the photographs (Pl. 1 D). Yano pointed out that the right pectoral fin had a large number of fibers near its base as well as along its margin. However, by a close examination of the photograph we can clearly distinguish the base of a dorsal fin, though it had slipped from the mid-dorsal line, and numerous rays hanging down from its rounded tip (Fig. 1). It seems that the pectoral fin was overlayed by a dorsal fin, thus presenting the appearance of an extremely long fin. Only this assumption can account for the unnatural appearance of the pectoral fin. At the base of the dorsal fin appear exposed structures that are judged to be fin-rays. The dorsal fin appears as long as the pectoral fin.

Trunk and segmental structures. The sketch indicates that the trunk was 6 m long and there were 14 thoracic vertebrae each with a rib-like process about 40 cm long, and the tail was 1.7 m long and comprised nine vertebrae. However, it is to be noted that the shape and number of vertebrae are not based on actual observations.

The curvature of the vertebral column is read from the photograph (Pl. 1 D), but vertebrae are not visible. On the left of the column we can see a row of 13 or 14 <-shaped structures (Fig. 1). Muscles in the interspaces between these structures were lost in part. Superficial parts of the posterior two or three of these structures were lost owing to putrefaction or physical damage, but it can be seen that the structures extend deep into the muscles. It follows that the structures are neither transverse processes of vertebrae

nor ribs but myocommata made up of strong connective tissues between myomeres. The stripes seen between the ribs behind the base of the pectoral girdle (Pl. 1 A, B) are also considered to be myocommata. These observations lead to the conclusion that the animal under investigation had primitive myomeres and well-developed myocommata.

Discussion

In the following discussion our determination of the taxonomic affiliation of the carcass is based chiefly on the features of the fins, head and neck, since the character of the animal is best exhibited in these portions.

Fin or limb? (Fig. 2). Vertebrates are divided into two fundamental categories, fishes and tetrapods (amphibians, reptiles, birds and mammals). The most evolutionarily pronounced and significant gap separating these two groups lie in the respiratory and locomotive organs. Fish live in water. They breathe by means of gills. The principal means of their locomotion are the trunk and tail, while the paired fins serve as stabilizing and maneuvering organs. Once primitive aquatic animals adapted to land life, the tail became an organ to keep body balance, and the paired fins developed into two pairs of limbs used for progression on land. Thus tetrapods evolved. The functional difference between fins and limbs is associated with the structural difference. The paired fins of fish are supported by fin-rays, whereas the limb supports in amphibians and higher vertebrates consist of skeleton. Some early amphibians retained caudal fin-rays as inheritance from their fish-like ancestors, but skeletal limb supports already coexisted in their limbs. Vertebrates that have returned from the land to the sea, such as the fossil marine reptiles, the living cetaceans, manatees and the semi-aquatic pinnipeds, have acquired secondarily fin-like limbs capable of being used for locomotion in water. Yet their limb supports are solely skeletal, though modification and increase or reduction of bone elements have occurred.

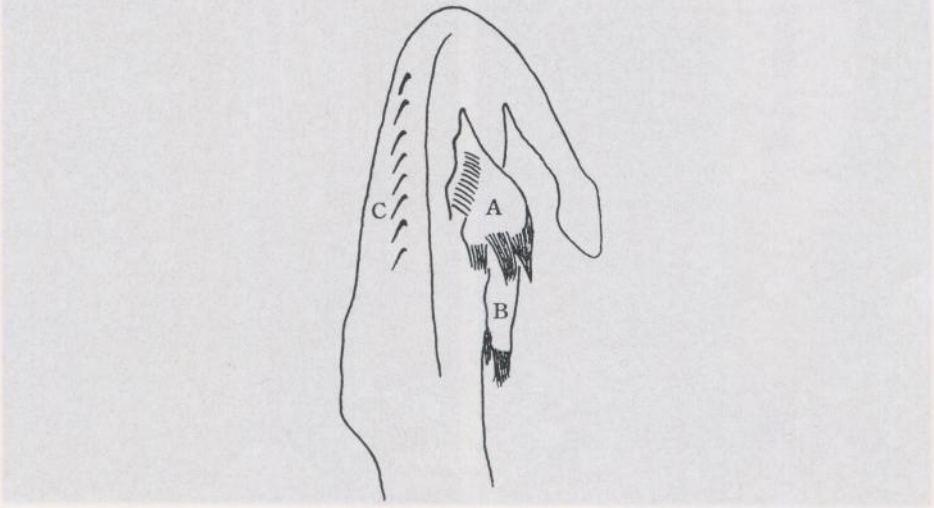

Fig. 1. Body structures of the carcass recognizable in the photograph taken from the back right. A, dorsal fin; B, right pectoral fin; C, myocommata.

The presence in the carcass of a number of fin-rays, which proved to be identical in chemical composition with the ceratotrichia of the basking shark (Kimura *et al.*, elsewhere in this volume), gives us a phylogenetic basis to draw the conclusion that the carcass represents a certain species of shark. The presence of the dorsal fin, though the fin was barely attached to the body and is difficult to recognize at first glance, offers strong support to this view. It can be read from the photographs that the dorsal fin had regularly arranged rays on its base and horny fibers on its tip.

Where had the jaws and gill-arches gone? (Fig. 3). Noticeable in the condition of the skull are its small size in relation to the body, the absence of the mandible and the lack of record of upper jaw teeth. On the assumption that the animal was a species of shark, based on the features of the pectoral fin and the presence of the dorsal fin, we attempted to explain the above-mentioned condition of the head part.

It was stated by the crew of the Zuiyo-maru that the carcass was half decomposed and the lower jaw had been lost. There is no reliable information on whether its upper jaw was present or not, nor is there any record of upper jaw teeth. It is well known that

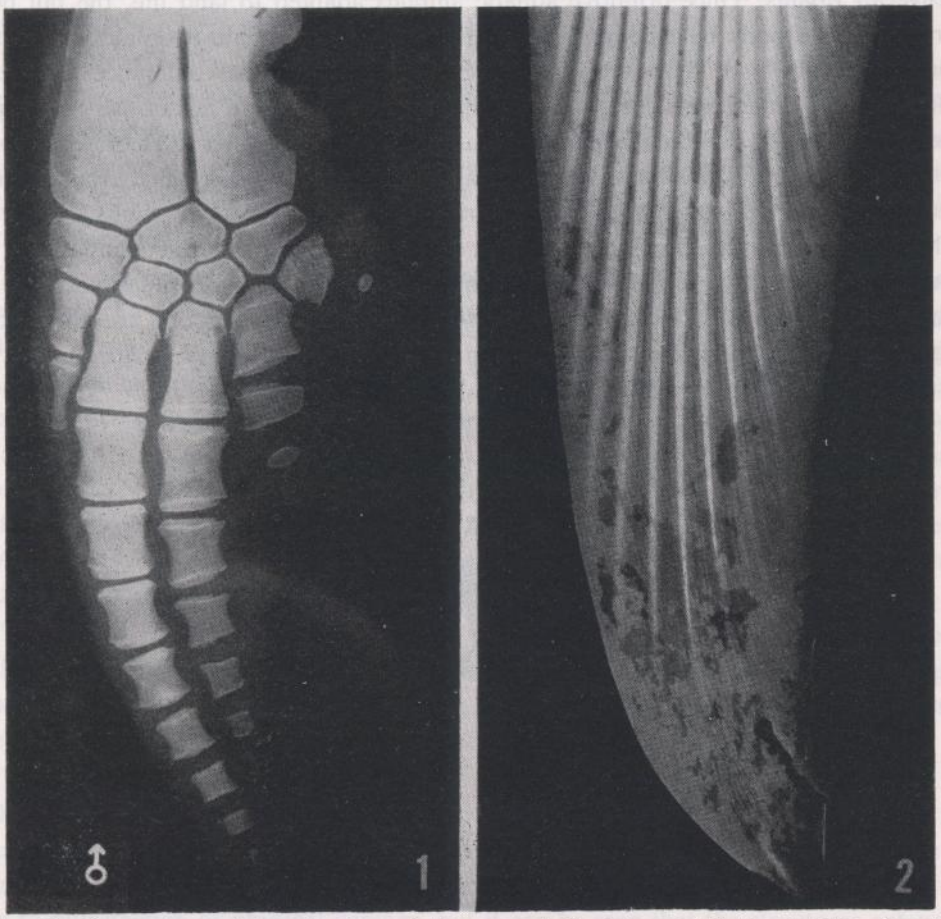

Fig. 2. Comparison of the structure of the pectoral fin between (1) the dolphin, *Stenella coeruleoalba* and (2) the blue shark, *Prionace glauca*.

when a shark is boiled or rotten, the upper and lower jaw cartilages can be easily removed from the cranium, without disconnecting both jaws from each other, and so can the five to seven pairs of gill-arches. Norman and Fraser (1949) state that as a carcass of the basking shark rots on the shore, or is buffeted against the rocks, the whole of the gristly skeleton of the jaws and gill-arches is soon washed away, leaving a somewhat curiously shaped box-like cranium.

Taking into consideration such phenomena peculiar to sharks, the unusual shape of the head and neck parts, with a disproportionally small skull and a long, slender neck, can be accounted for by the loss of the jaws and gill-arches in the course of decomposition of the carcass. It is quite likely that the carcass had retained only the neurocranium and cervical vertebrae and thus presented the appearance of a long-necked animal.

There remains the question of whether the process of decomposition of a shark carcass under experimental conditions is similar to that in natural conditions. What will happen with the pelvic fins and skeleton in the stage when the jaws and gill-arches become detached? The carcass of a shark stranded at Nemuro, Hokkaido, in the beginning of September, 1977 seems to give an answer to this question. This carcass was 5 m long, and in a more advanced stage of decomposition than in the Zuiyo-maru carcass, with almost all muscles washed away and the vertebrae wholly exposed. The jaws and gill-arches were missing, and the cranium had a somewhat turtle-like appearance. The vertebral column was complete from the cervical to caudal vertebrae. The pectoral and pelvic fins were damaged at their appexes but still remained. The results of this experiment undertaken by nature support the view that the Zuiyo-maru carcass was a giant shark which had lost

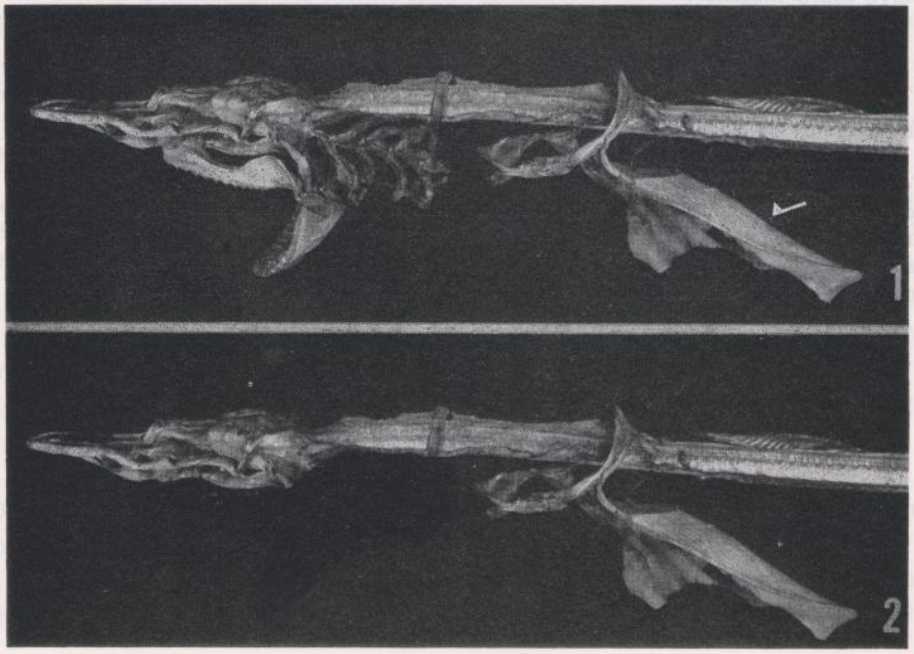

Fig. 3. Skeleton of the gummy shark, *Mustelus manazo*, showing the normal skeletal plan (top) and appearance when the jaws and gill-arches are removed (bottom).

its jaws and gill-arches.

Conclusion

We consider that the carcass trawled by the Zuiyo-maru off New Zealand belongs to a species of giant shark, e.g. barking shark, on the following comparative morphological bases: 1) It had pectoral and dorsal fins with fin-rays characteristic of fish, 2) there were myocommata in the dorsal muscles, and 3) the loss of the jaws and gill-arches can account for the strange appearance of the head.

Finally, we wish to express our thanks to Professor Fujio Yasuda, Tokyo University of Fisheries, and Dr. Toru Taniuchi, the University of Tokyo, for providing information and materials.

Postscript

For all our efforts to secure specimens of giant sharks for comparison, none were available. We wish to find an opportunity in the future to make further comparative studies using giant sharks such as the basking shark, which is occasionally caught in or near Japanese waters from early spring to early summer.

It is not uncommon that large-sized sharks washed ashore were described as sea monsters. If various species of giant sharks are deposited in the National Science Museum and other public institutions, they will be useful in working out such problems as that of the Zuiyo-maru monster.

References

Corbert, E. H. (1955): Evolution of the vertebrates. Wiley, New York.

Gans, C. and T. S. Parsons. (1964): A photographic atlas of shark anatomy. Academic Press, New York and London.

Matthews, L. H. (1950): Notes on the anatomy and biology of the basking shark. Proc. Zool. Soc. London, 120 (3): 535～576.

Norman, J. R. and F. C. Fraser. (1949): Field book of giant fishes. Putnam's Sons, New York.

Romer, A. S. (1965): The vertebrate body. Saunders, Philadelphia and London.